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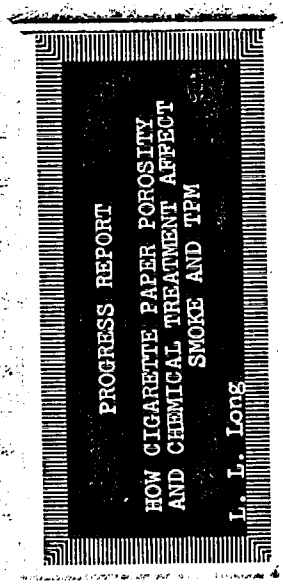

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P H I L I P M O R R I S I N C .

RESEARCH CENTER

PROGRESS REPORT

HOW CIGARETTE PAPER POROSITY AND CHEMICAL TREATMENT AFFECT SMOKE AND TPM

Prepared by:

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day file 10
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Richmond, Virginia

August 21, 1961

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I. Introduction

At the Thirteenth Annual Tobacco Chemists' Conference, Dr. Milton O. Schur presented a paper entitled " The Design of Low Yield Cigarettes." In this paper Dr. Schur discussed the control of cigarette "TPM"[1] through the use of naturally porous and ventilated cigarette papers.[2] To confirm the data reported by Dr. Schur and to learn some of the effects of cigarette paper characteristics (porosity[1] and chemical treatment[1]) on one of our cigarette blends, a study was undertaken at the Research Center.

Further, the outcome of such a study could be of great value in the development of new cigarettes.

Our study was confined to commercially available, naturally porous papers with three levels of chemical treatment. A nonfilter cigarette containing Parliament blend was chosen as the medium of study.

II. Conclusions and Recommendations

A. Conclusions

The conclusions listed below are based on the data presented in this report. In applications of this data to other cigarettes (filter or nonfilter) consideration must be given to such things as tobacco blend, cigarette weight, (or density), and the cigarette filter (on filter cigarettes).

1. Limited control of cigarette TPM is available by cigarette paper chemical treatment or cigarette paper porosity, and through combinations of chemical treatment and paper porosity. A practical range of control through a combination of cigarette paper, chemical treatment and paper porosity is approximately 7 mg/ cigarette of TPM (see Appendices, Graph II).

2. Control of TPM through cigarette paper chemical treatment and paper porosity is accompanied by an increase or decrease in static burning time in the same direction as the change in TPM (see Appendices, Graphs II and III.

3. Static burning time does not vary appreciably with cigarette paper chemical treatment or paper porosity. The area of greatest effect is at the high porosities (35-45 seconds). Below 35 seconds of porosity slight differences in static burning time are noted, however,

1 A glossary of terms is included in the Appendices.

2 Some of the theoretical aspects of cigarette TPM control are also discussed in this paper.

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these are of the order of 30 seconds or under (see Appendices, Graph III).

4. A plot of TPM against percentage air dilution[3] (Appendices, Graph I) yields a curve with a very high slope. The extreme slope of this curve means that very small changes in cigarette air dilution can yield a rather large change in TPM. Therefore, unless air dilution is carefully controlled, one may expect a wide range of TPM which may offset any apparent advantage indicated by the plot of TPM vs. chemical treatment (Appendix III, Graph II). This is especially important since cigarette air dilution is a function of parameters of cigarette construction other than cigarette paper characteristics. Such things as cigarette density,[4] uniformity of cigarette density, moisture, width of filler shreds, tightness of glue seam, etc., can have a very large effect on air dilution.

It is also important to note that small variations of paper porosity are not visible since the papers used were carefully selected for uniformity in this respect.

5. The appearance of the cigarette ash is quite satisfactory over a wide range of chemical treatments. Only those papers containing high phosphate give poor ash (see Appendix II, Table I, Ecusta 900 and Schweitzer H968-C and Appendix VII for photographs).

6. Special Cigarette Papers - Schweitzer H968-C cigarette paper is a very high phosphate (1.38%), mechanically ventilated cigarette paper. The high phosphate content of this paper accomplished two things: (1) a high static burning rate (11.8 min.), and (2) a very poor ash. The high level of ventilation (paper porosity of 10 seconds) resulted in a cigarette which gave a moderately low TPM (25 mg/cigarette), however, the cigarettes had a prohibitive level of air dilution (56%).

B. Recommendations

A thorough examination of the data presented here indicate considerable need for additional study to further define and

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3 See Glossary in Appendices for an explanation of the term.

4 The effect of cigarette weight (density) can be seen in Appendix II, Table I where measurements were taken with weight as a variable. Also note the effect of weight on percent air dilution. Two cigarette papers, Ecusta 543 and Ecusta 995, were used for these measurements.

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complete the relationships of cigarette paper characteristics with TPM and static burning. Further, the data clearly show a relationship between TPM and air dilution (an overall cigarette characteristic which is influenced by several parameters in addition to cigarette paper) which is not adequately defined at this time.

The following recommendations are submitted for consideration toward a program for completing this investigation.

1. It is recommended that the experiments in this report be repeated to establish the validity of the data obtained. It is expected that improved precision in the data can be obtained now that we have better facilities for cigarette making. Any new data could be obtained on 70 or 85 mm cigarettes, thus rendering the data directly comparable to a production cigarette model.

2. It is recommended that additional cigarette papers be obtained for all types (fast, medium, and slow burning) at higher Greiner porosities to further define the spread indicated between the curves for these paper types. Additional cigarette papers should also be obtained for the fast burning paper in the low porosity range (10-15 seconds) to complete this curve.

3. It is recommended that additional papers of intermediate porosities be obtained to be used in a more complete investigation of the relationship between cigarette air dilution and TPM. The curve indicated by the present data is quite steep in slope. The exact shape and slope of this curve is quite critical since such small changes in air dilution can cause a large change in TPM.

4. It is further recommended that other parameters affecting TPM and static burning such as tobacco blend, moisture, cigarette density, filler size and width of tobacco cut, and filter be included in future investigations.

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III. Experimental Procedure, Results, and Discussion

A. Experimental Procedure

The experimental procedure followed for this study is basically outlined in memorandum for (Appendix VIII). However there are several points not apparent from this memorandum.

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1. The cigarette papers which we used were selected from those commercially available to give as wide a coverage of cigarette paper chemical treatment and paper porosity as possible. Adhering to commercially available papers restricted our study somewhat, particularly on the fast burning (citrate treated) papers. Only two levels of porosity (22 seconds and 42 seconds) were available in the fast burning papers.

2. Nonfilter cigarettes were chosen to eliminate the influence of filter variation on TPM and air dilution.

3. Parliament blend was chosen as one being of considerable interest in the area of burning rate control when our investigation began.

4. Cigarettes of 90 mm length were used due to the fact that we were unable to make any other length during the period our study began. This, of course, means that the data (TPM, RTD, etc.) cannot be compared directly with data obtained on cigarettes of standard lengths; however, an extrapolation of this data to other cigarettes should be valid.

The cigarette papers which we used are described in Appendix II, Table I, and in the experimental procedure. Appendix VIII.

B. Discussion of Results

The data as presented in this report in the form of Table I and Graphs I to IV, are discussed below:

1. The effect of Cigarette Air Dilution on TPM

Perhaps the most important point developed from this study is illustrated by Graph I. Here the TPM (mg/cigt.) is plotted against percentage air dilution. This plot shows no apparent affect of cigarette paper chemical treatment on TPM. All points for the slow, medium, and fast burning papers fall on one curve. Bear in mind that the cigarettes were of uniform circumference and selected at the same weight (See Table I).

One point, that for the special high percentage phosphate, ventilated paper (Schweitzer H968C-3) does not conform to the pattern of the other papers as shown in Graph I. You will note, however, that the dilution is very high (56%).

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This particular curve is very steep in slope which means that minor changes in air dilution (whatever the cause--small changes in paper porosity, cigarette construction, etc.) will result in a relatively large change in TPM. This, of course, makes it extremely difficult to do more than estimate the range of change in TPM that may be expected from a particular cigarette paper characteristic as plotted in Graph II.

2. The Effect of Cigarette Paper Characteristics on TPM and Static Burning

In Graph II (TPM vs. cigarette paper porosity) separate curves are indicated for each cigarette paper chemical treatment. However, the curve for the medium burning paper lies approximately 0.4 mg/cigt. of TPM above that for the fast burning paper from the 20 second porosity level upward. Using our normal test procedures (20 smoking machine ports per test) this level of difference cannot be shown significantly different. At the 15 - 20 second porosity level the curve for the medium burning paper lies about equal distance between the slow and fast burning papers which means that during normal TPM testing differences between the medium burning paper and the other two may not be demonstrable. At the lower porosities (15 seconds and under) all three curves converge.

As contrasted to the medium burning, the curves for the fast burning and slow burning papers are sufficiently apart at all points above the 20 second porosity level to be detectably different by our normal TPM method.

Perhaps more data would better locate the medium burning paper curve to a point where differences could be noted, particularly at the higher Greiner porosities (30 second and upward).

In Graph III (static burning vs cigarette paper porosity) a distinct difference in cigarette paper effect on static burning is shown between all three papers at the higher Greiner porosity (25 seconds and upward). Below 25 seconds small differences exist; however, these are of the order of 0.6 minutes of static burning and under. At 20 seconds the difference between the fast and slow burning paper curves are of the order of 0.4 minutes which is not detectably different by our normal testing method (normal level of difference detectability is 0.6 minutes or more).

3. Cigarette Ash

A photograph of statically burning cigarettes made from the different cigarette papers illustrates the effect of chemical treatment (or cigarette paper burning rate) on the quality of the cigarette ash. The two cigarettes, numbers VII and VIII

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(see Appendix VII), are high phosphate papers (0.69% and 1.38% respectively). The photograph shows that the ash on these cigarettes is darkened and flakey. The very high phosphate paper (1.38%) is considered worse than the other high phosphate paper which contains 0.69% phosphate (normal phosphate treatment is 0.5%). All of the normal citrate treated and phosphate treated papers give a satisfactory ash.

4. The Effect of Cigarette Weight on TPM and Static Burning

The data in Table I on cigarette papers, Ecusta 543 and Ecusta 995, where TPM and static burning were measured as a function of cigarette weight show that both TPM and static burning time are directly related to cigarette weight. In each case, as the cigarette weight increases, the TPM and static burning time increases. The effect on static burning is greater than that for TPM.

5. Special Cigarette Paper--Schweitzer H968C-3

Schweitzer paper H968C-3 (a specially ventilated, very high phosphate paper) does not conform to any of the patterns of the other papers. Its high phosphate content gives a very slow burning rate and a resulting poor ash. Its mechanical ventilation (resulting in an air dilution of 56%) gives a very low TPM, but a smoke which is quite unsatisfactory due to the high cigarette air dilution. The cigarette is difficult to light and smoke.

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APPENDIX I

GLOSSARY OF TERMS

1. TPM - Total Particulate Matter: moisture, smoke solids, and other weighable materials collectable on a glasswool filter pad which removes 99.9% of all particles 0.3 micron or larger.

2. Porosity: the term porosity as used in this report is a measure of the porous nature of paper as measured by a Greiner porosity meter. Greiner porosity is the time (in seconds) required for 50 cc of air to pass through a circular cross section of paper 25 mm in diameter; thus, increasing time (higher seconds) means a decreasingly porous paper.

3. Static Burning (or free burning rate): time in minutes required to burn 40 mm of a cigarette under static conditions in still air.

4. Percent Air Dilution or Percent Total Dilution: that portion of air exiting the cigarette (1050 cc/min. under standard smoking conditions) which does not pass through the entrance (or coal) end of the cigarette.

5. Cigarette Paper Chemical Treatment: cigarette papers are normally treated with chemicals to influence the burning rate. Cigarette papers are normally divided into three broad groups according to their treatment:

   Slow burning papers - treated with 0.4 - 0.7% monoammonium phosphate

   Medium burning papers - treated with 0.6 - 0.95% sodium or potassium citrate

   Fast burning papers - treated with 1.2 - 1.6% sodium or potassium citrate

6. Ventilated Cigarette Papers: cigarette papers that have been reduced in porosity*(made more porous) by mechanical means--i.e. electric sparks which burn holes or fine needle-like points which punch holes.

* As measured by a Greiner Porosity Meter

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$\frac{\pi \times 63.08}{180} = 1.11$

$\frac{35.54 \times \pi}{180} = 0.968$

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Jenny Brittle has shown that with Playa Cgt. opt. W-99/68 delumd also same a cgt @ 17-17½ mg.

3²K/2

32.6 1.9 and Dilution

30.7 .9

27.63

Appendix II

Table I

Summary of Data

I. Slow Burning Papers

	Ecusta 900	Ecusta 555	Ecusta 794F	Schweitzer H968C-3
Chemical Treatment				
Citrate, %	0	0	0	0
Phosphate, %	0.4-0.7	0.4-0.7	0.4-0.7	high phosphate
Porosity target, sec.	45	20	10	10
Weight range, gm.	Centre			
Moisture, %	11.8	12.0	11.3	11.2
Circumference, mm	24.9	24.7	25.0	24.9
Total Dilution, %	9.8	17.4	36.6	55.7
Total RTD, in. H_2O (cm)	8.87	8.19	6.82	6.25
Static Burning				
Average time, min.	10.99	9.38	9.24	11.83
Mg (cigt. burned)/min.	52	60	61	48
TPM (60 mm smoked)				
Mg/cigt.	32.6	27.1	22.4	25.1
Puffs/cigt., avg.	11.5	10.5	10.8	11.8
Nicotine (60mm smoked), mg/cigt.	1.45	1.24	1.12	1.25
Average porosity, sec.	41	20	9	10
Phosphate by analysis, %	0.69	0.48	0.55	1.38

II. Medium Burning Paper

	Ecusta 543 1st Range	Ecusta 543 2nd Range	Ecusta 543 3rd Range	Schweitzer 136-1	Ecusta 553
Chemical Treatment					
Citrate, %	0.65-0.95	0.65-0.95	0.65-0.95	0.55-0.65	0.55-0.65
Phosphate, %	0	0	0	0	0
Porosity target, sec.	45	45	45	22	12
Weight range, gm	1.225-1.265	1.265-1.305	1.305-1.345	--	Centre
Moisture, %	11.7	11.7	11.7	12.3	11.8
Circumference, mm	24.6	24.6	24.6	24.8	24.9
Total Dilution, %	11.7	12.0	12.5	15.8	33.6
Total RTD, in. H_2O	9.12	9.86	10.52	9.68	7.55
Static burning rate					
Average time, min.	9.48	9.87	10.23	9.40	9.15
Mg (cigt. burned)/min.	58	57	57	60	62
TPM (60 mm smoked)					
mg/cigt.	29.5	30.0	30.8	27.8	22.9
Puffs/cigt., avg.	10.8	11.6	--	10.5	10.3
Nicotine (60mm smoked), mg/cigt.	1.29	1.29	1.33	1.26	1.10
Average porosity, sec.	38	--	--	26	12
Phosphate by analysis, %	--	--	--	--	--

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Appendix II, Table I (cont.)

III. Fast Burning Papers

	Ecusta 515	Ecusta 995 1st Range	Ecusta 995 2nd Range	Ecusta 995 3rd Range
Chemical Treatment				
Citrate, %	1.2-1.6	1.6	1.6	1.6
Phosphate, %	0	0	0	0
Porosity target, sec.	42	22	22	22
Weight range, gm.		1.225-1.265	1.265-1.305	1.305-1.345
Moisture, %	12.3	11.3	11.3	11.3
Circumference, mm	24.8	24.9	24.9	24.9
Total dilution, %	9.2	20.5	24.1	18.7
Total RTD, in. H_2O	8.87	7.73	8.19	9.46
Static burning rate				
Average time, min.	9.30	8.75	9.03	9.25
Mg (cigt. burned)/min.	60	63	63	63
TPM (60 mm smoked)				
Mg/cigt.	29.6	26.6	25.9	26.0
Puffs/cigt., avg.	10.5	10.5	10.3	10.0
Nicotine (60mm smoked), mg/cigt.	1.33	1.18	1.15	1.15
Average porosity, sec.	41	22	--	--
Phosphate by analysis, %	--	--	--	--

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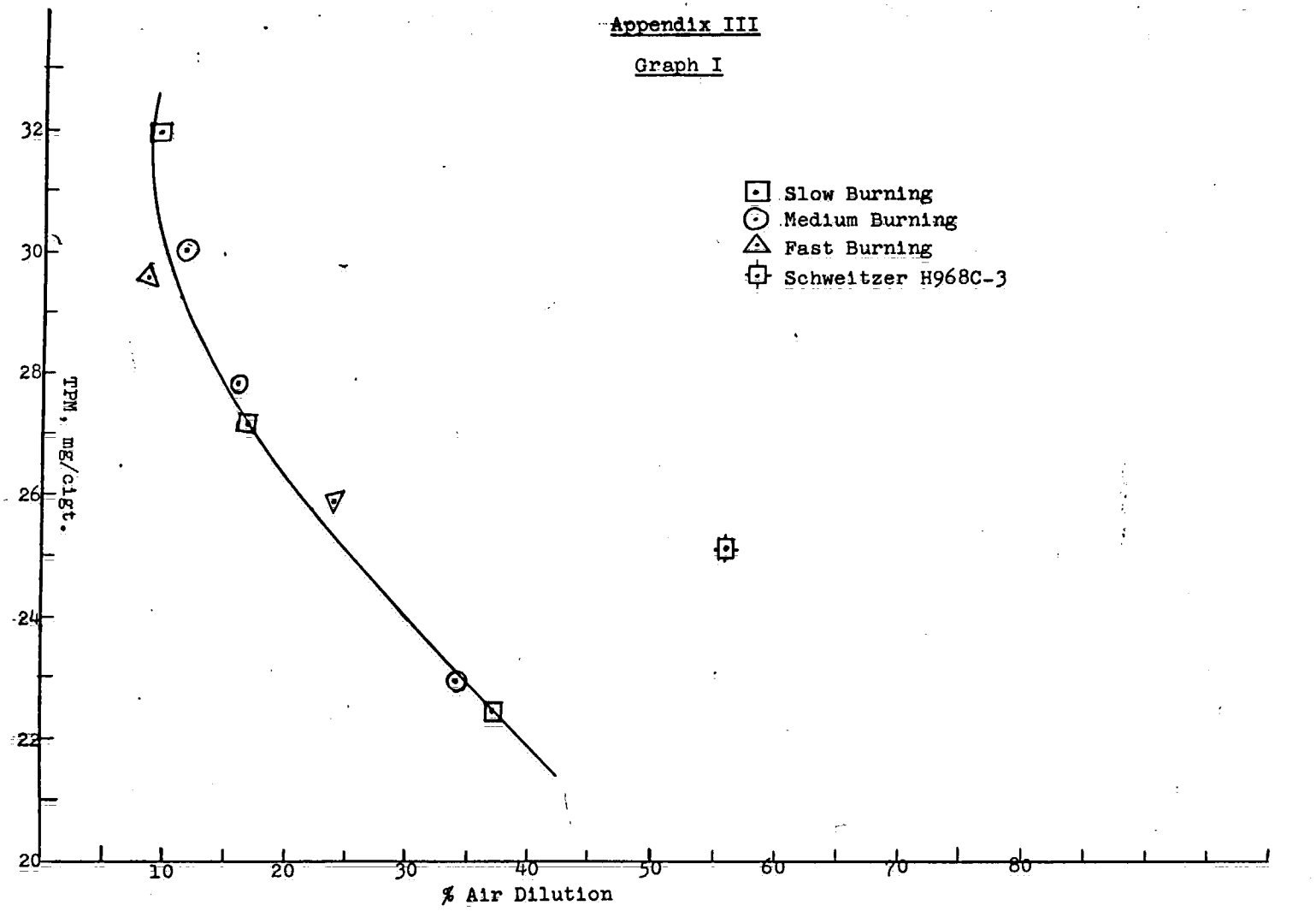
Appendix III

Graph I



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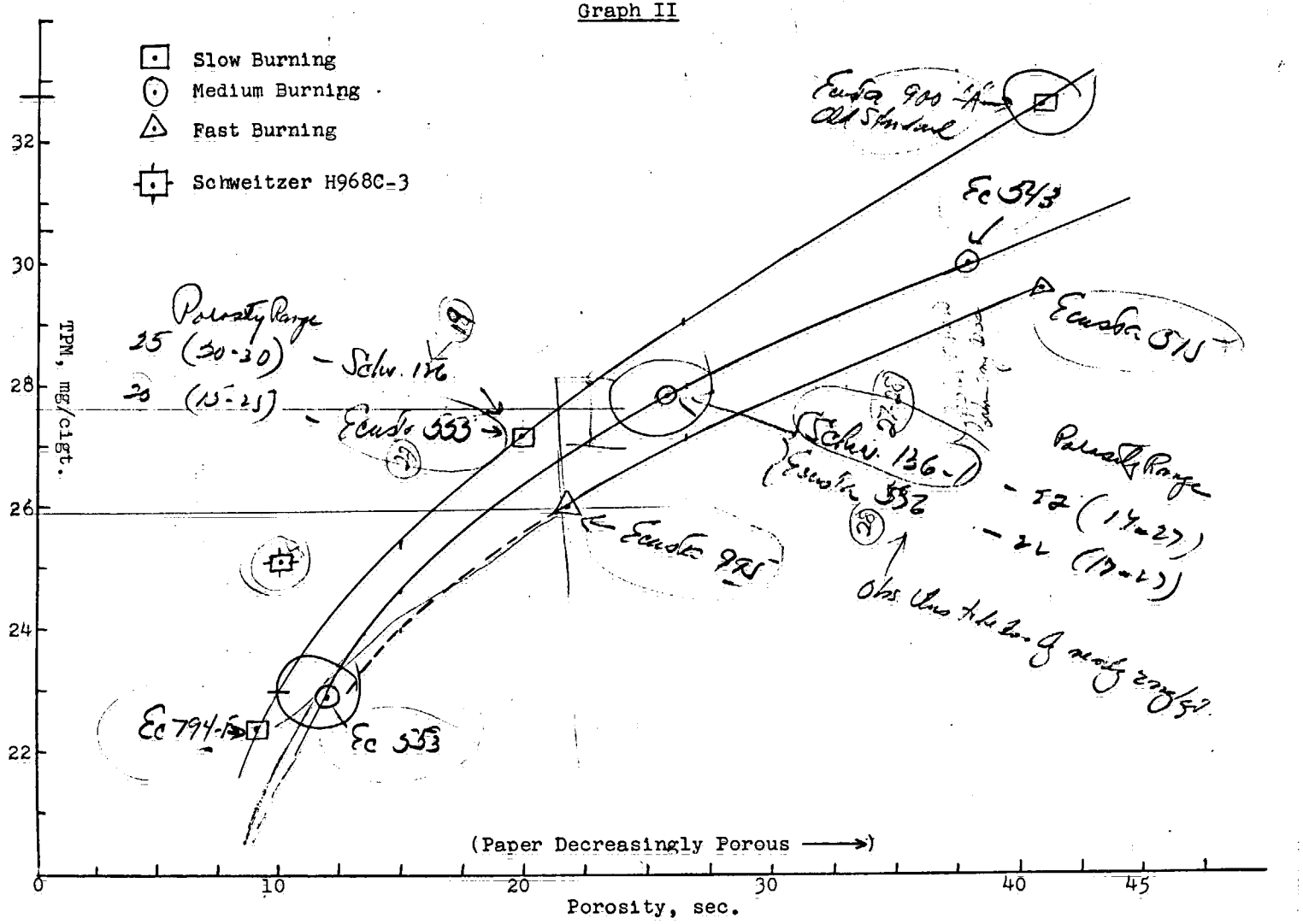
Appendix IV

Graph II



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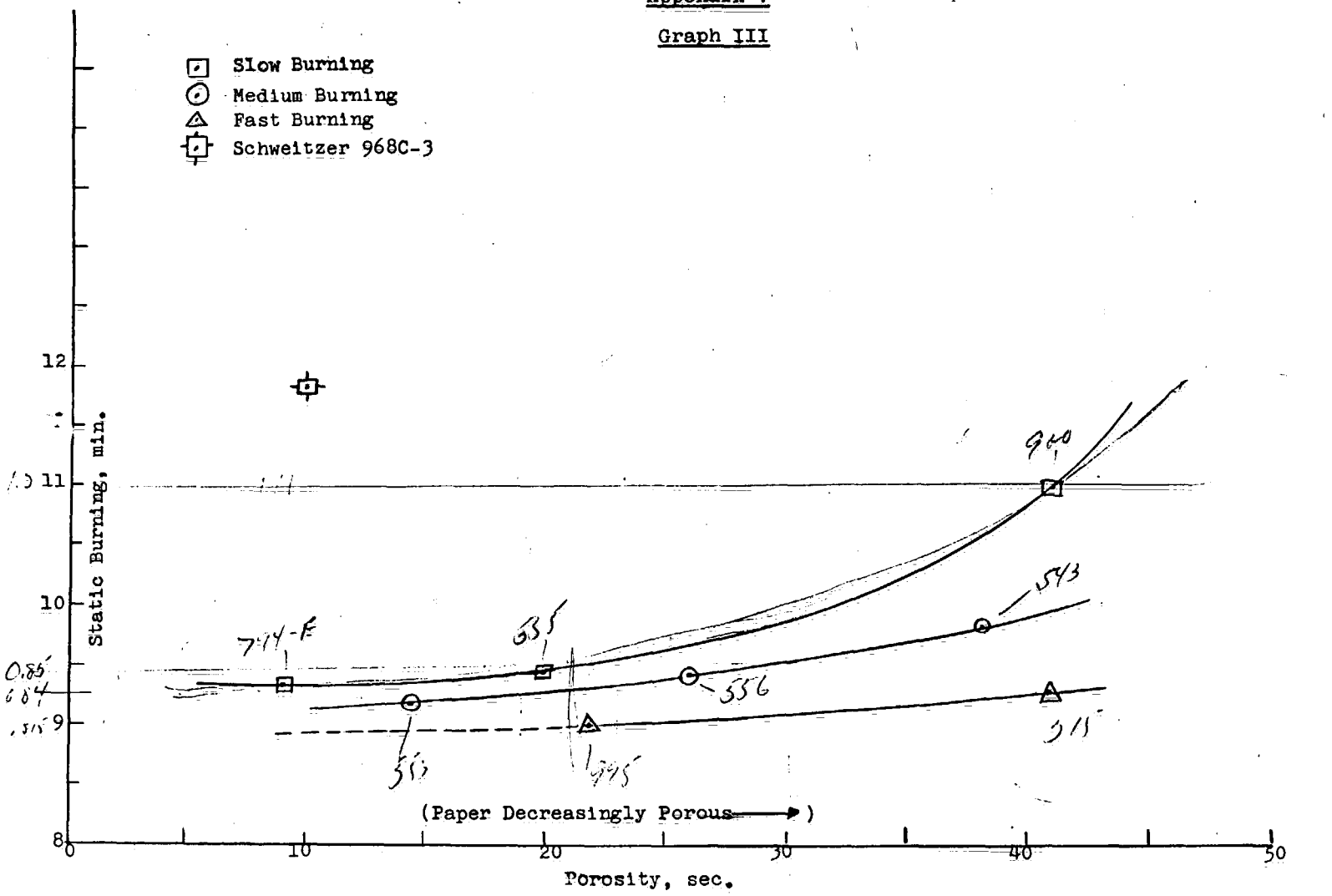
Appendix V

Graph III



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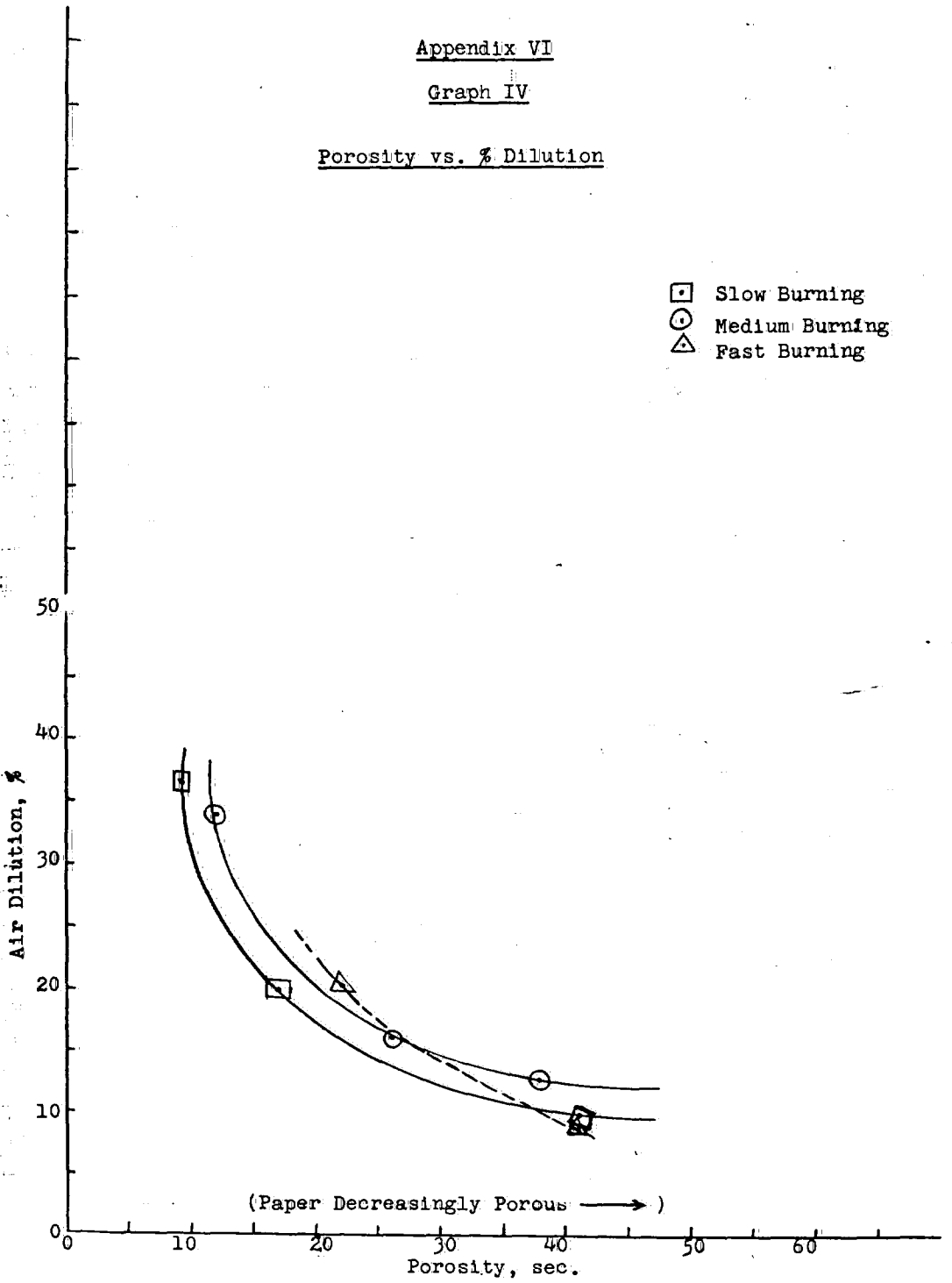
Appendix VI

Graph IV

Porosity vs. % Dilution



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Appendix VII

PHILIP MORRIS INCORPORATED

INTER-OFFICE CORRESPONDENCE

RICHMOND, VIRGINIA

To: Mr. L. L. Long

Date: November 21, 1960

From: V. C. Johnson

Subject: Whiteness of Ash - Mi-258-Project 4000.

Nine coded cigarettes were received to be photographed to show the difference, if any, in the whiteness of ash.

Two of the nine cigarettes showed a real difference in whiteness, the ash was much darker and rougher than the other seven cigarettes examined. These two cigarettes were wrapped in paper that had a high phosphate content. I could see little or no difference in the whiteness of the other 7 cigarettes.

The cigarettes were allowed to burn statically and were photographed in color.

CIGARETTE NO.	CODE	DISCRIPTION OF PAPER
1	136-1	A citrate paper
2	515	A citrate paper
3	543	A citrate paper
4	553	A citrate paper
5	555	.48% Phosphate
6	794F	.55% Phosphate
7	900	.69% Phosphate
8	H-968C-3	1.38% Phosphate
9	995	A citrate paper

V. C. Johnson

LSH:mar

cc: Dr. R. H. Blackmore
Mr. R. M. Wiley
Mr. J. C. Holmes
Mr. J. T. Butler

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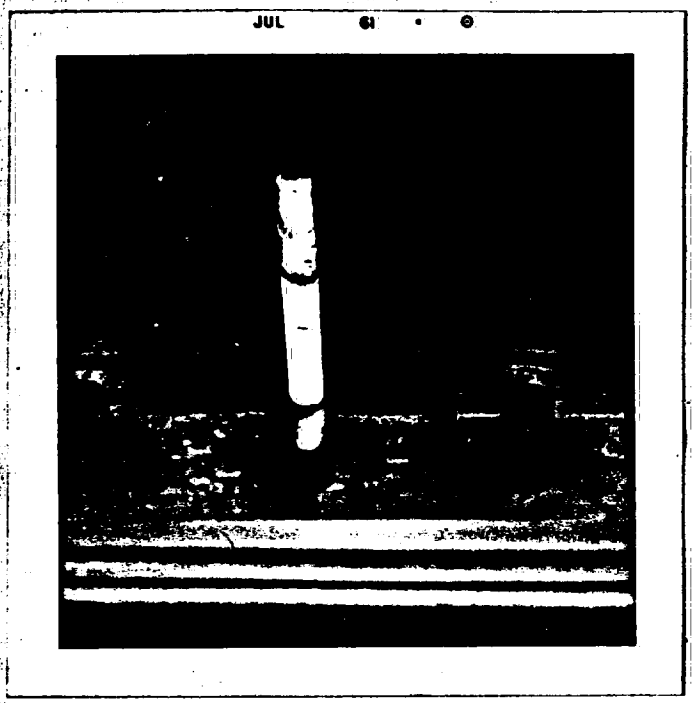
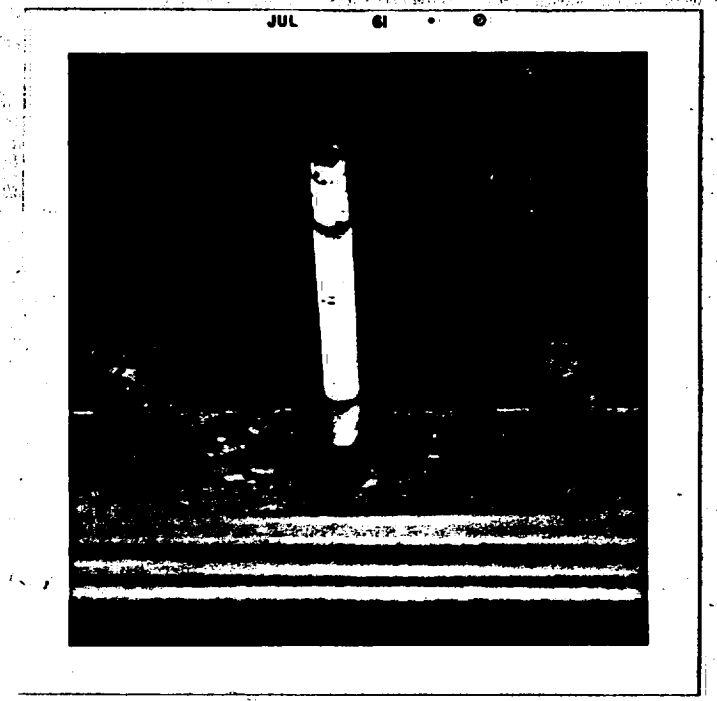
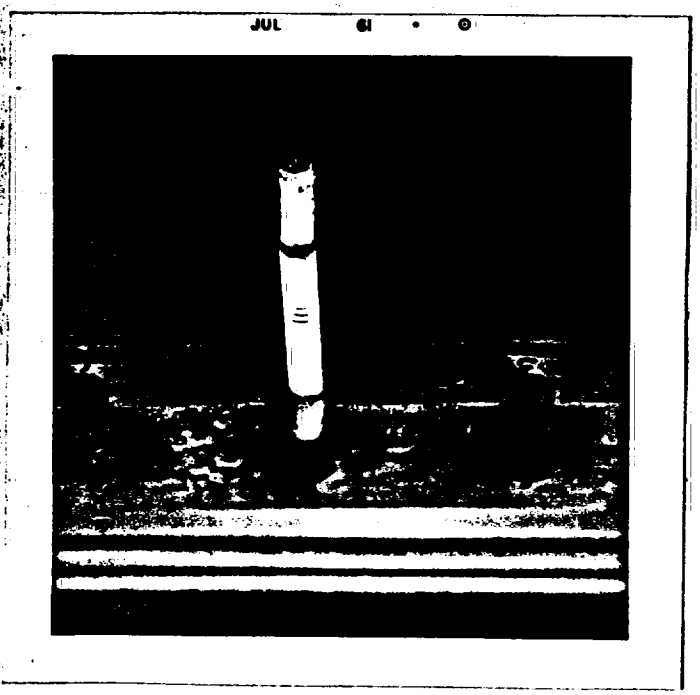
WHITENESS OF ASH



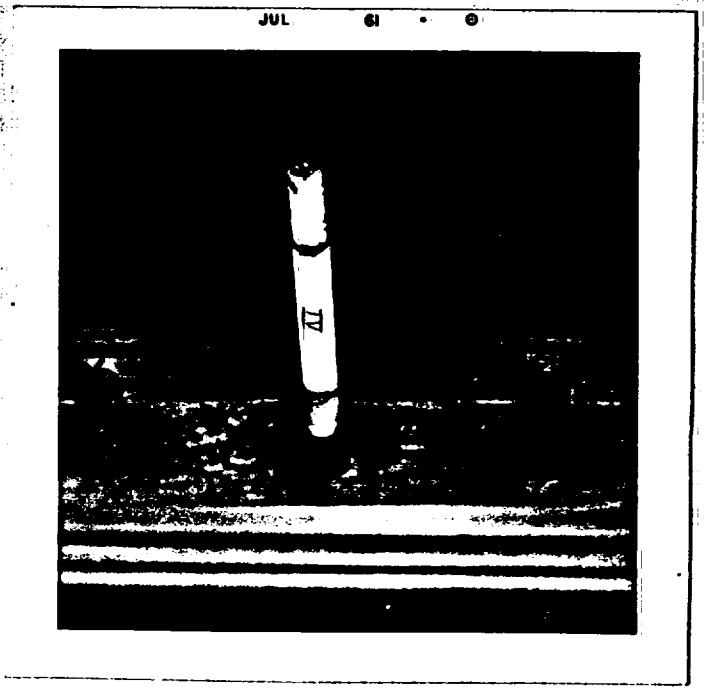
Cigarette No. 1 - Code 136-1, Citrate Paper.



Cigarette No. 2 - Code 515, Citrate Paper.



Cigarette No. 3 - Code 543, Citrate Paper.



Cigarette No. 4 - Code 553, Citrate Paper.

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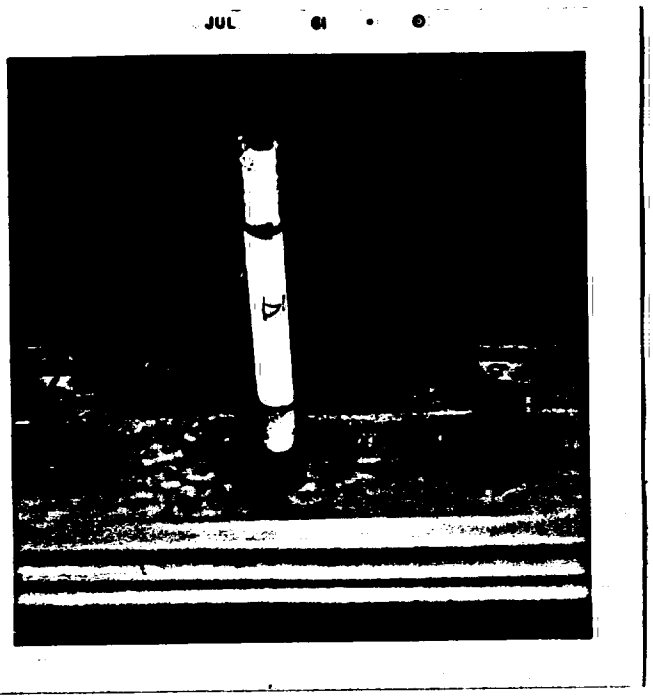
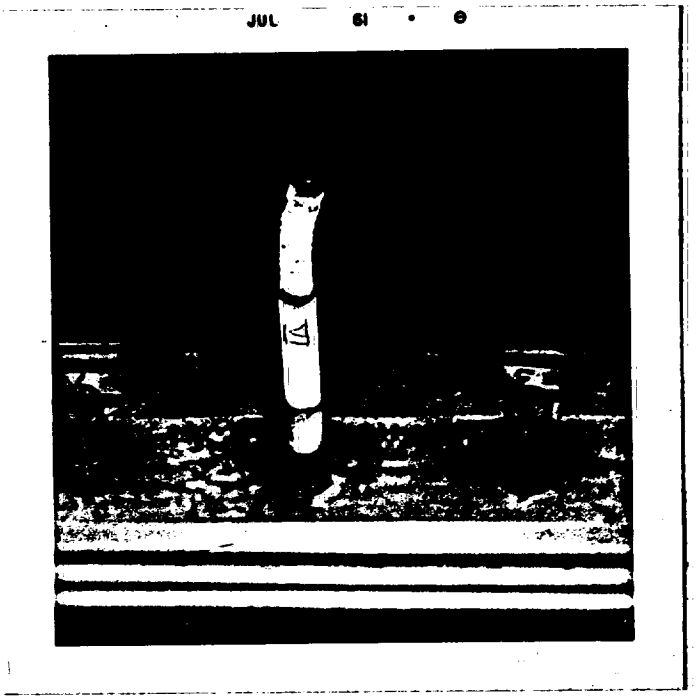
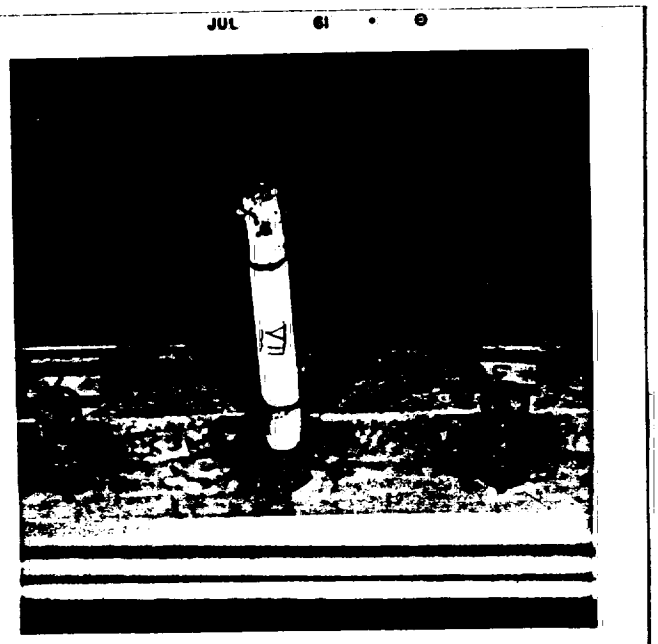
WHITENESS OF ASH



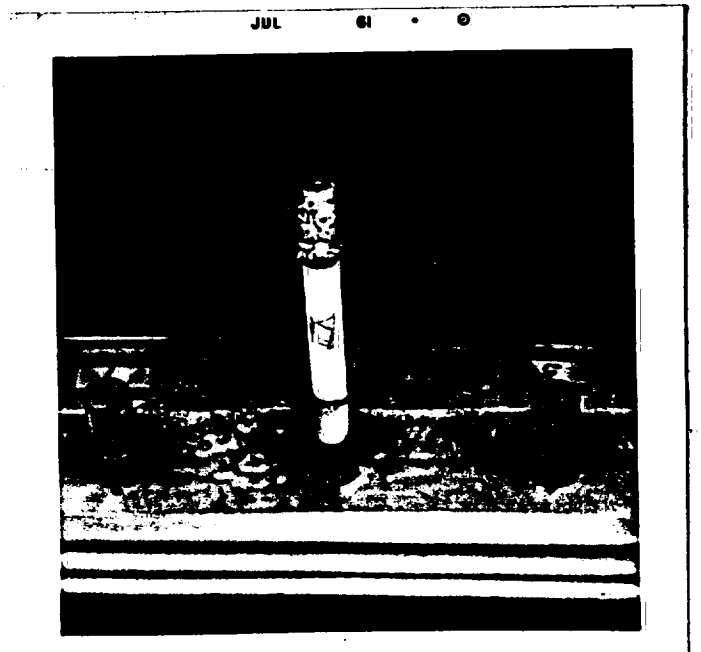
Cigarette No. 5 - Code 555,
0.48% Phosphate.



Cigarette No. 6 - 794F,
0.55% Phosphate.



Cigarette No. 7 - 900,
0.69% Phosphate.



Cigarette No. 8 - H-968C-3,
1.38% Phosphate.

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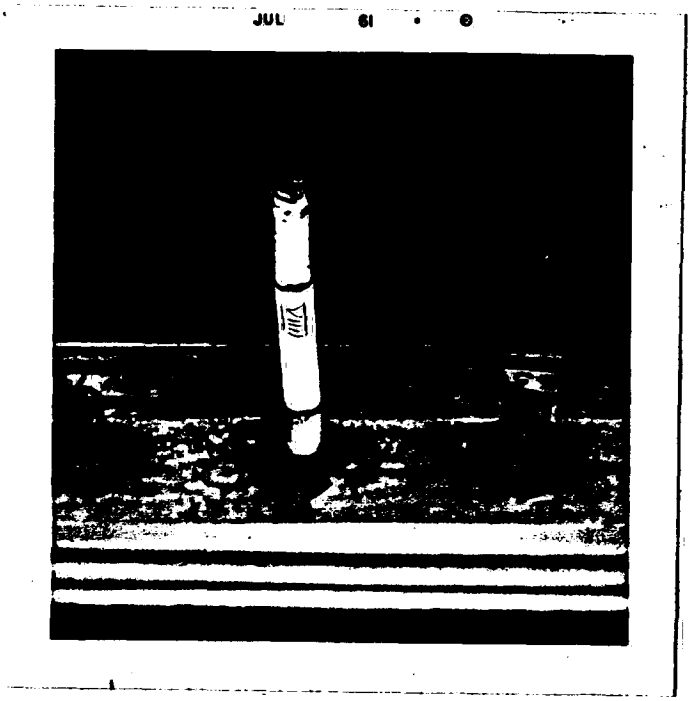
WHITENESS OF ASH



Cigarette No. 9 - Code 995,
Citrate Paper.

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Appendix VIII

Dr. R. B. Seligman August 5, 1960

L. L. Long

Cigarette Paper Characteristics vs. TPM and Static Burning

After discussions with T. Budne an experimental design has been developed to study the effect of cigarette paper characteristics (chemical treatment and porosity) on the TPM delivery and static burning of cigarettes. Eight cigarette papers are to be used in this experiment (see attached table). Cigarettes will be made from each of these papers using Parliament filler, 25.0 mm circumference, and a 90 mm rod length. The target cigarette density will be the same as Parliament cigarettes. During cigarette manufacture, samples of the cigarette paper (approximately 30 ft.) will be taken just before, at the middle, and at the end of each run with a different paper. These samples will be used to establish the cigarette paper characteristics.

The cigarettes will be sampled and evaluated as follows:

1. After conditioning for 48 hours at 75°F and 60% R.H. the cigarettes will be weight selected in three groups to obtain approximately 500 cigarettes at each weight range. The weight ranges to be used are target 1.265 - 1.305 gms, 1.225 - 1.265 gms, and 1.305 - 1.345 gms.

2. Standard tests to be performed are shown in the table below:

	Sample	Monitor	Length Smoked
TPM	16 ports	4 ports	60 mm
Nicotine	16 ports	4 ports	60 mm
Static burning	40 cigts.	20 cigts.	40 mm
Dynamic burning	same as TPM	same as TPM	60 mm
% dilution	100 cigts.		
RTD	100 cigts. (same as dilution)		

All of these tests are to be performed on the weight selected cigarettes at the center weight range for each paper and at all weight ranges on one of the paper samples. Should differences due to weight occur on the one sample, then all samples will be run as indicated above.

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4. On one sample and at one weight range the cigarettes for TPM and nicotine are to be segregated into groups of four according to RTD. Examination of the data according to RTD (assuming the RTD of the cigarettes is not uniform within weight selected groups) will establish any relationship that may exist between TPM, nicotine, and dynamic burning, and RTD.

5. Percent dilution and RTD data will be used to establish any relationship between these variables and paper porosity. It will also aid in checking the quality of the glue lines on the Chico cigarettes.

/hj
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Cigarette Paper and Characteristics

Code	Chemical Treatment Citrate (%)	Chemical Treatment Phosphate (%)	Porosity Target (seconds)
I. Slow Burning Papers			
Ecusta 900	0	0.4-0.7	45
Ecusta 555	0	0.4-0.7	20
Ecusta 794F	0	0.4-0.7	10
Schweitzer H969C-3	0	1.0	10
II. Medium Burning Papers			
Ecusta 543	0.65-0.95	0	45
Schweitzer 136-1	0.55-0.65	0	22
Ecusta 553	0.55-0.65	0	12
III. Fast Burning Papers			
Ecusta 515	1.2-1.6	0	42
Ecusta 995	1.6	0	22

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